

## **REFRIGERATED DISPLAY MERCHANDISER WITH IMPROVED AIR CURTAIN**

[001] This application is also a continuation-in-part of copending application serial number 10/374,640, filed February 26, 2003.

### **BACKGROUND OF THE INVENTION**

[002] The present invention relates generally to refrigerated display merchandisers of the type used in supermarkets, mini-marts, convenience stores and other commercial establishments for displaying and merchandising refrigerated or frozen products for sale. More particularly, the present invention relates to open-front refrigerated display merchandisers of the type wherein a curtain of cold refrigerated air is passed downwardly across the open front product display region of the merchandiser.

[003] Refrigerated display merchandisers, also commonly referred to as display cases, having open front display regions are commonly used in supermarkets, mini-marts, convenience stores and other commercial establishments for displaying and merchandising refrigerated or frozen products for sale. The open front nature of such display cases permits the consumer to simply reach into the product display region to select and remove a product for purchase without the inconvenience of needing to open a door to access the product. Customarily, a curtain of cold refrigerated air is passed downwardly at a relatively high velocity across the open front of the display case to form an invisible boundary between the product display region and the region of the store in front of the display case. This air curtain not only helps retain cool refrigerated air within the product display region of the display case, thereby cooling the display product on the shelves of the display case, but also functions to isolate, to a certain extent, the product display region from the ambient air within the store. Ambient air that does enter into open product display region undesirably causes increased energy consumption by increasing the cooling demand on the refrigeration system associated

with the display case. Further, such ambient air may also cause a local temperature rise within the product display region sufficient to result in an undesirable rise in product temperature that could adversely impact upon product quality.

[004] A problem encountered with when passing a curtain of refrigerated air downwardly across the open front of the product display region of the display case lies in the entrainment of ambient air into the stream of refrigerated air forming the air curtain. Turbulence exists at the boundary between the relatively high velocity curtain air and the generally quiescent ambient air lying in front of the display case. As a result of such turbulence, some ambient air is undesirably entrained into the air curtain. Multiple air curtain display cases have been developed in the prior art to address this entrainment problem. For example, display cases having two adjacent, parallel, but independently generated, air curtains of refrigerated air are common in the art. Typically, such as disclosed by Maehara in U.S. Patent 4,633,677, the outermost air curtain has a slightly higher temperature than the innermost air curtain, so as to protect the colder innermost air curtain from the impact of ambient air entrainment.

[005] Also, it is well known in the art to establish a third air curtain of relatively high temperature ambient air outwardly of one or two refrigerated air curtains as a means of reducing entrainment of ambient air from the store into the refrigerated air curtains. Abraham, in U.S. Patent 4,267,706, discloses establishing an ambient air curtain outwardly of an innermost refrigerated air curtain, with the outer ambient air curtain being directed downwardly parallel to and adjacent to the inner refrigerated air curtain. Beckwith et al, in U.S. Patents 3,648,482 and 3,850,003, MacMaster et al, in U.S. Patent 3,827,254 and Roberts, in U.S. Patents 5,345,778 and 5,357,767, each disclose establishing an ambient air curtain outwardly of a pair of refrigerated air curtains. The curtain closest the product display region of the display case is coolest, while the center curtain is at a temperature slightly warmer than the innermost curtain, but substantially cooler than the outermost ambient air curtain. The center curtain of warmer refrigerated air serves to buffer the innermost colder refrigerated air curtain from warm air intrusion

from the outermost ambient air curtain. The outermost curtain of ambient air is directed substantially vertically downwardly, either parallel to and adjacent the center air curtain or slightly inwardly toward the center air curtain, so as to preclude refrigerated air from the center and innermost refrigerated air curtains from spilling out of the product display region of the display case. The outermost ambient air curtain itself ideally spills into the store near the base of the display case so as to not be drawn into the air return inlets through which the refrigerated air curtains return to the evaporator compartment.

[006] Although generally effective to substantially reduce the amount of entrainment of ambient air into the recycled refrigerated air as compared to a single air curtain design, significant entrainment still occurs in the case of refrigerated merchandisers having two or three air curtains. It is generally recognized that entrainment is reduced when adjacent air curtains in such multiple air curtain designs have relatively the same velocity so that shear instabilities at the interface between air curtains is minimized. Therefore, in typical prior art merchandisers, the respective discharge velocities of the separate air curtains, that is the discharge velocities of the respective air streams as they pass out of their respective nozzles at the top of the display case, are designed to be substantially equal, be there two or three air curtains present. However, as the air curtains flow downwardly, the outer air curtain tends to spread and spill into the store thereby reducing in velocity, while the inner air curtain tends to increase in velocity due to buoyancy effects and the addition of air from within the refrigerated display case. As a result, as the air curtains pass downwardly, the shear instabilities at the interface of adjacent air curtains increase, resulting in increased entrainment of higher temperature, moister air into the inner air curtain of refrigerated. Consequently, a need exists for an improved air curtain system that addresses the problem of entrainment into the inner air curtain of refrigerated air without significant expense.

### **SUMMARY OF THE INVENTION**

[007] The refrigerated merchandiser of the present invention includes a display case defining a product display region having an open-front isolated from the ambient air of the store by means of a downwardly directed inner air curtain of relatively cold refrigerated air and a downwardly directed outer air curtain, most advantageously of relatively warmer air. In accordance with the present invention, the discharge velocity of the outer air curtain is maintained at a velocity at least 1.4 times the discharge velocity of the inner air curtain, and most advantageously in the range of about 1.4 to about 2.4 times greater than the discharge velocity of the inner air stream. In a preferred embodiment, the outer air curtain comprises ambient air.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[008] Figure 1 illustrates a side elevation profile of a preferred embodiment of a refrigerated merchandiser having an open-front display case with a dual stream air curtain separating a first environment within the display case from a second environment external of the display case; and

[009] Figure 2 is a graphical presentation showing the variation of load demand on the cooling system associated with the refrigeration merchandiser as the air curtain velocity ratio changes.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

[010] Referring now to Figure 1, the refrigerated merchandiser 10 includes an outer cabinet 12 and an inner cabinet liner 20 that defines within its bounds an open-front product display region 30. The outer cabinet has a base 13, a rear wall 14 extending upwardly from the back of the base 13, a top wall 15 extending forwardly from the rear wall and a pair of side walls 16 extending vertically from the base 13 to the top wall 15 and forwardly from the rear wall 14. The inner cabinet liner 20 has a top panel 28, a

back panel 26, a bottom panel 24 and opposed side panels 23 which together bound the open-front product display region 30. Each of the cabinet base 13, rear wall 14, top wall 15 and side walls 16 is insulated, as in conventional practice, to thermally isolate the interior of the cabinet 12, including the product display region 30, from excessive heat transfer therethrough.

[011] Perishable product 80 being merchandized may be displayed on shelves 18 disposed within the product display region 30 and upon the upper surface of the bottom panel 24. The product display region 30 has an open front 25 so as to permit consumers to not only view, but also reach into the product display region 30 to select and remove items of product 80 that they desire to purchase. Product display region 30 is cooled in a conventional manner to a desired product temperature, typically to a temperature between -10°F to less than about 40°F, depending upon what product is being merchandised therein and whether the product is frozen or non-frozen.

[012] The refrigerated merchandiser 10 further includes a refrigeration compartment 40, typically disposed in the portion of the display cabinet 12 between the base 13 and the bottom panel 24, as depicted in Figure 1, wherein components of the refrigerant system, typically a tube coil evaporator 50 and a air mover 60, such as for example one or more fans, are housed. However, it is to be understood that the specific type of air mover employed is not relevant to or limiting of the present invention. As in conventional practice, refrigerant passing through the tubes of the evaporator 40 cools air passing over the surface of the evaporator tubes. The refrigerant is typically supplied from a remote refrigeration unit located elsewhere within the store. However, it is to be understood that the present invention may also be employed on stand-alone refrigerated merchandisers that include their own refrigeration unit for providing the cold refrigerant.

[013] An air circulation duct 32 is formed between the rear wall 14 and the top wall 15 of the outer cabinet 12 and the back panel 26 and top panel 28, respectively, of the inner cabinet liner 20. Air mover 60 serves to direct air from air inlet 42 through the compartment 40 so as to traverse evaporator 50, and thence through duct 32 to a first air outlet 34. As noted before, this circulating air has been cooled to a desired temperature as it traverses the evaporator 50. From the first air outlet 34, the cool refrigeration air is directed via vanes provided within the first air outlet 34 downwardly along first path across the open front 25 of the product display region back to air inlet 42. Thus, the refrigerating air is recycled and repeatedly recirculated through the compartment 40 and duct 32 to converse energy expended in cooling the refrigeration air. Further, through the afore-described cooling arrangement, a cool air curtain 45 is formed across the open-front product display region 30 from top to bottom thereof. To provide further cooling air directly to the product display region 30, a plurality of openings 24 may be provided in the back panel 26 through which a portion of cold refrigerating air circulating through duct 32 may pass directly into the product display region 30. This refrigerating air will also be drawn by the air mover back through the air inlet 42 into the compartment 40 to be recirculated.

[014] A second air outlet 70 is provided outwardly of the first air outlet 34 at the top front of the cabinet 12. In contrast to existing refrigerated merchandisers, second air outlet 70 serves to direct relatively warm air generally downwardly along a second path lying outwardly of the first path followed by the cool refrigerating air. In this manner, a relatively warm outer air curtain 65 is formed outside, i.e. further away from the product display region 30, of the relatively cool inner air curtain 45. The relatively warm outer air curtain 65 serves as a buffer between the relatively cool inner air curtain 45 and the ambient environment of the store. Further, when the outer air curtain 65 reaches the base region of the display cabinet 12, it spills outwardly into the store rather than into the air inlet 42 in the forward end of the base portion of the cabinet. Consequently, the entrainment of warm air into the relatively cool inner air curtain and subsequent passage

through inlet 42 into the compartment 40 is minimized, thereby reducing energy consumption in cooling the recirculating refrigeration air.

[015] The first air outlet 34 and second air outlet 70 are located at top and forward region of display case 12, with the second air outlet 70 being located outwardly of the first air outlet 34, that is, closer to the front of the display cabinet 12. As noted previously, first air outlet 34 is in communication with duct 32 and directs relatively cool air driven by air mover 60 downwardly across open front of the product display region 30 to form the inner air curtain 45. The second air outlet 70 is in fluid communication with a source of relatively warm air, for example ambient air from the store, and directs relatively warm air driven by a second air mover 72 associated therewith downwardly to form an outer air curtain 65.

[016] The outer air curtain 65 is directed downwardly at a discharge velocity that is at least 1.4 times greater than the discharge velocity of the inner air curtain 45. The term discharge velocity refers to the velocity of the air stream discharging from its respective air outlet at the top of the display case 30. Ergo, the discharge velocity of the inner air curtain 45 is the velocity of the air stream discharging from air outlet 34 and the discharge velocity of the outer air curtain 65 is the velocity of the air stream discharging from air outlet 70. Most advantageously, the discharge velocity of the outer air curtain 65 is maintained at a level of about 1.4 to about 2.4 times faster than the discharge velocity of the inner air stream 45.

[017] Referring now to Figure 2, the vertical axis thereof represents the load reduction factor, which is the refrigeration load of the dual air curtain compared to the load for an inner air curtain only, and the horizontal axis represents the ratio of the velocity of the outer air curtain in that of the inner air curtain. Accordingly, the lower the load reduction factor, the more effective is the dual air curtain. As illustrated in Figure 2, the effectiveness of dual parallel air curtains as a barrier in reducing passage of flow across the air curtain is maximized by maintaining the ratio of the discharge velocity of the

outer curtain to the discharge velocity of the inner curtain within the range of from about 1.4 to about 1.8. Maintaining the air curtain velocity ratio within this range minimizes the velocity gradient, and therefore shear instabilities, between the adjacent air curtains along the length of the interface between the adjacent air curtains, thereby resulting in less entrainment of air from the higher velocity air curtain into the lower velocity air curtain. Therefore, an very effective separation barrier may be maintained between two environments through use of the present invention through a dual air curtain of parallel streams of a first and a second fluid by maintaining the discharge velocity of the outer air stream a level of about 1.4 to about 1.8 times faster than the discharge velocity of the inner air stream.

[018] The aforementioned description is exemplary rather than limiting. Many modifications and variations of the present invention may be recognized by those skilled in the art in light of the above teachings that will fall within the spirit and scope of the present invention. The preferred embodiments of this invention have been disclosed. Accordingly, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For this reason the following claims should be studied to determine the true scope and content of this invention.